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GB 1102803
US 3557387A
US 3106371A
"Artifical hand controlled by nerves" New Scientist No. 382 pub 12/3/64 pp. 668-671
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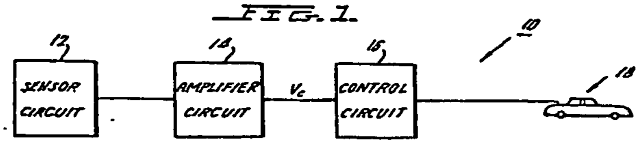
(54) Toy controlled by myoelectric potentials

(57) A toy 18 capable of producing at least one human perceptible output is controlled by myoelectric potentials generated by an operator of the toy. A sensor 12, adapted to contact the skin of the operator of the toy, provides an electrical signal having a magnitude proportional to the myoelectric potential developed by the operator of the toy. An amplifier circuit 14, responsive to the electrical signal provided by the sensors, generates a control signal whose magnitude varies as a function of the myoelectric potential. A control circuit 16, responsive to the control signal, operates the toy as a function of the myoelectric potential.

FIG. 1



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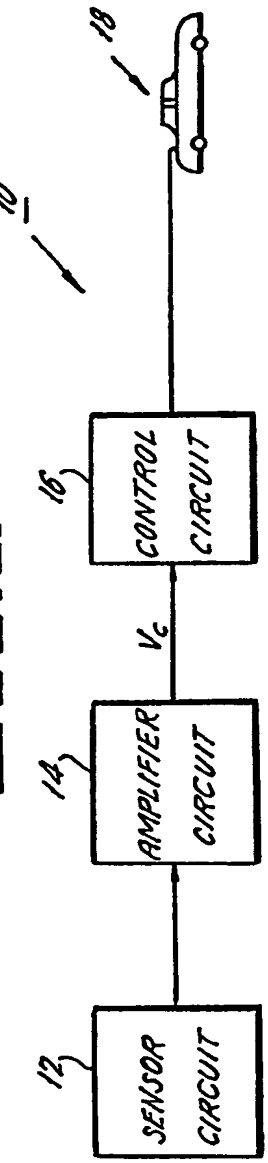

10
12
SENSOR CIRCUIT
14
AMPLIFIER CIRCUIT
Vc
16
CONTROL CIRCUIT
18

FIG. 1.

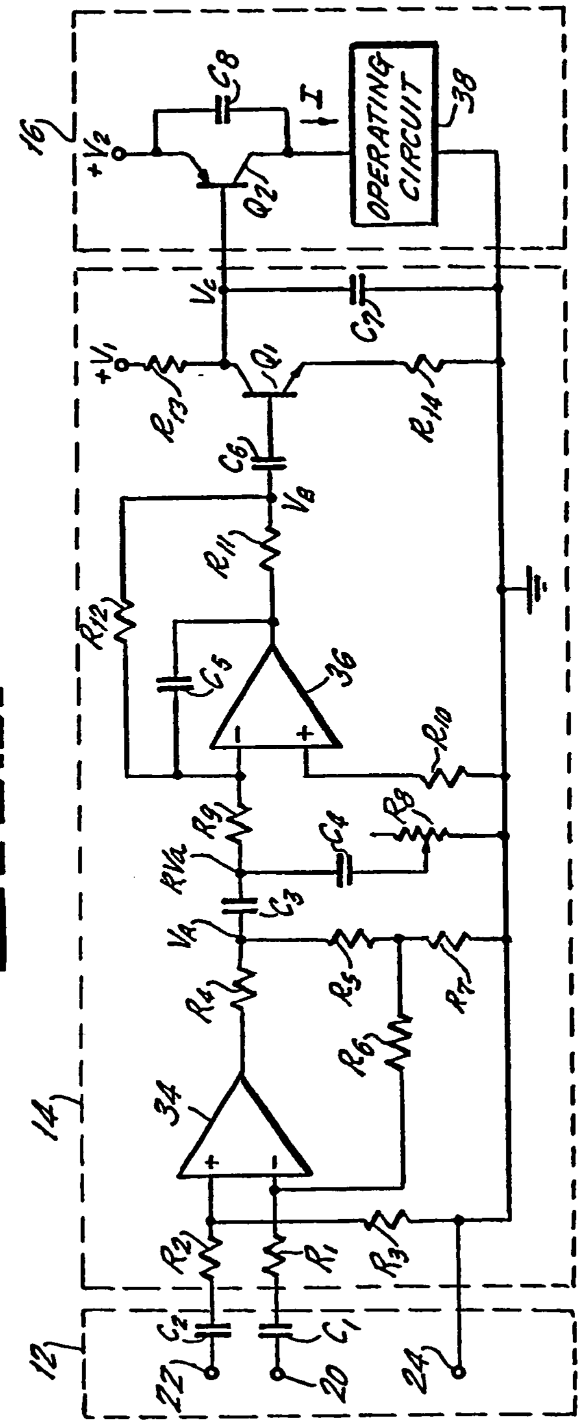

16
+V2
C8
I
Q2
OPERATING CIRCUIT
38
Vc
C7
+V1
Q1
R13
R14
C6
VB
R11
R12
C5
36
R10
R9
RVA
C4
R8
C3
VA
R5
R7
R4
R6
34
14
R2
R1
R3
C2
C1
12
22
20
24

FIG. 2.

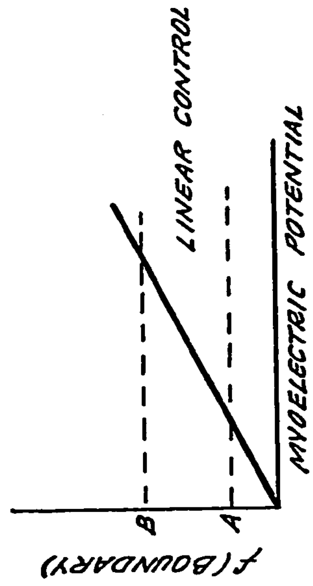


FIG. 5.

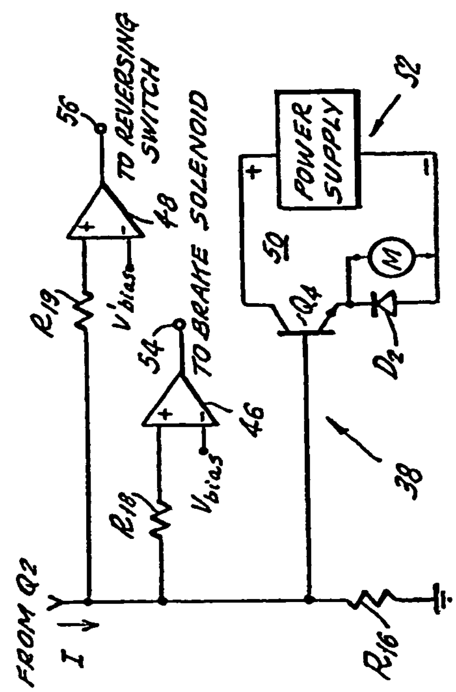


FIG. 6.

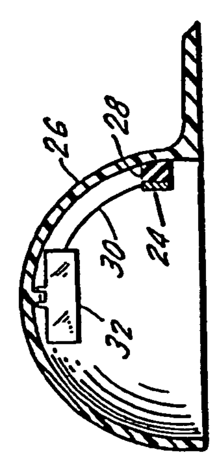


FIG. 3.

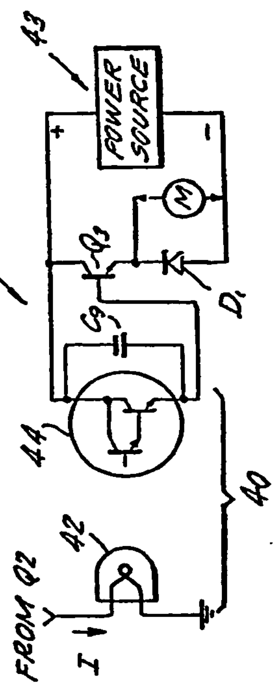


FIG. 4.

FIG. 7.

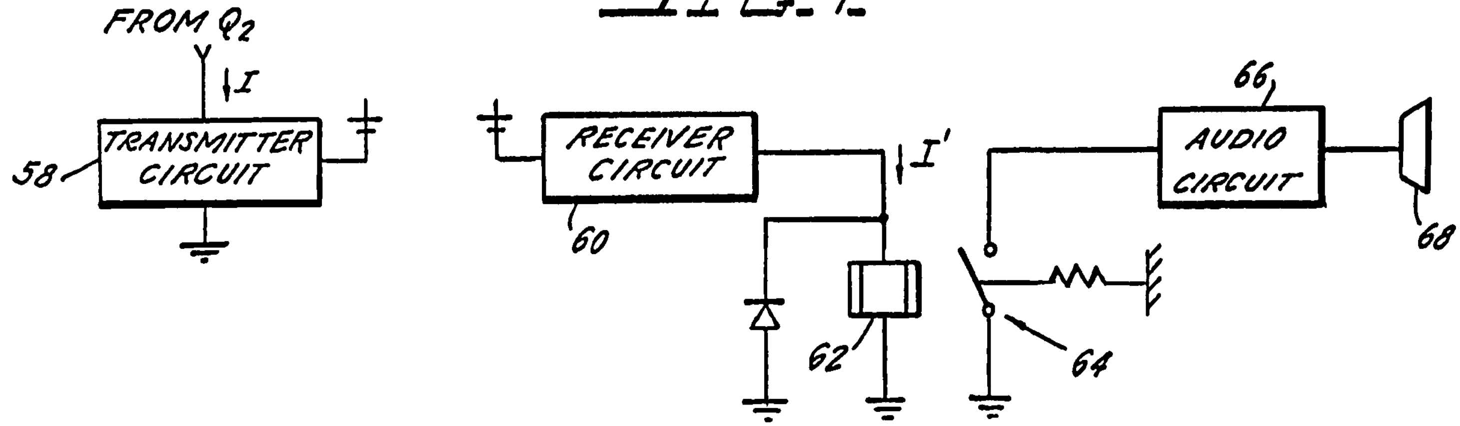
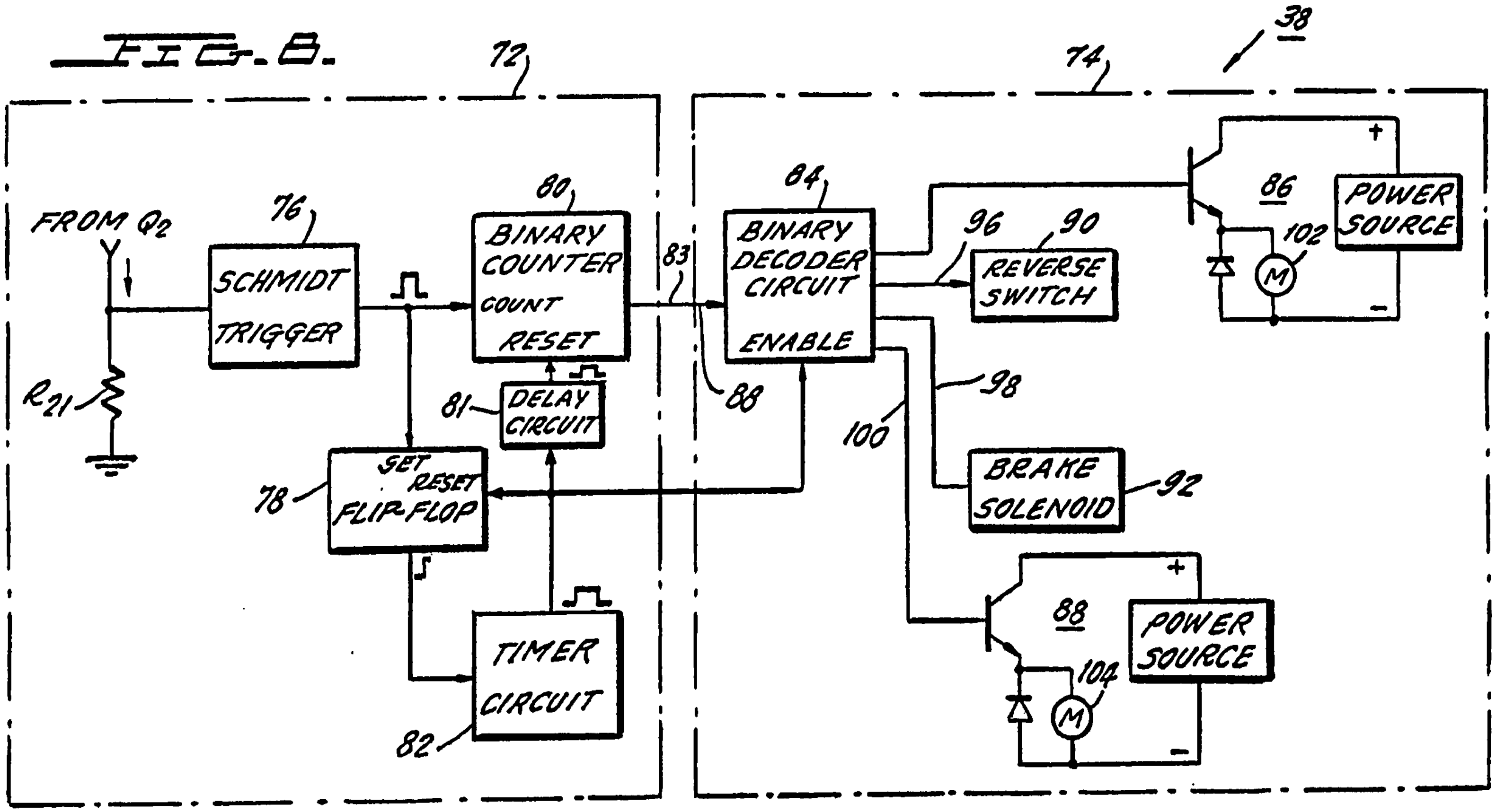

FROM Q_2
I
TRANSMITTER CIRCUIT
58
RECEIVER CIRCUIT
60
I'
62
64
AUDIO CIRCUIT
66
68

FIG. 8.


38
72
74
FROM Q_2
R_{21}
SCHMIDT TRIGGER
76
BINARY COUNTER COUNT RESET
80
DELAY CIRCUIT
81
SET RESET FLIP-FLOP
78
TIMER CIRCUIT
82
83
BINARY DECODER CIRCUIT ENABLE
84
88
96
90
REVERSE SWITCH
98
BRAKE SOLENOID
92
100
86
102
M
POWER SOURCE
+
-
88
104
M
POWER SOURCE
+
-

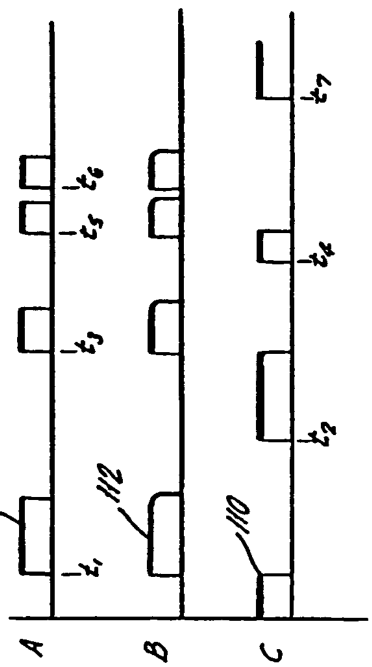


FIG. 11.

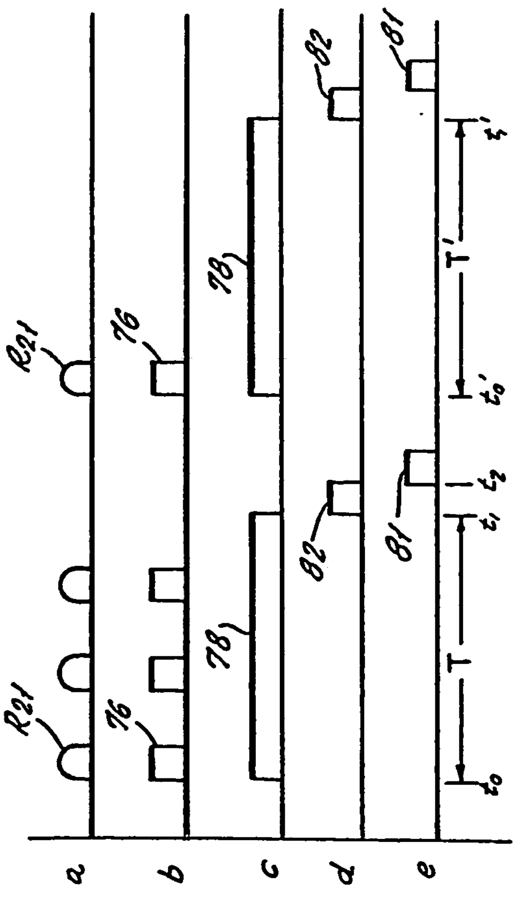


FIG. 9.

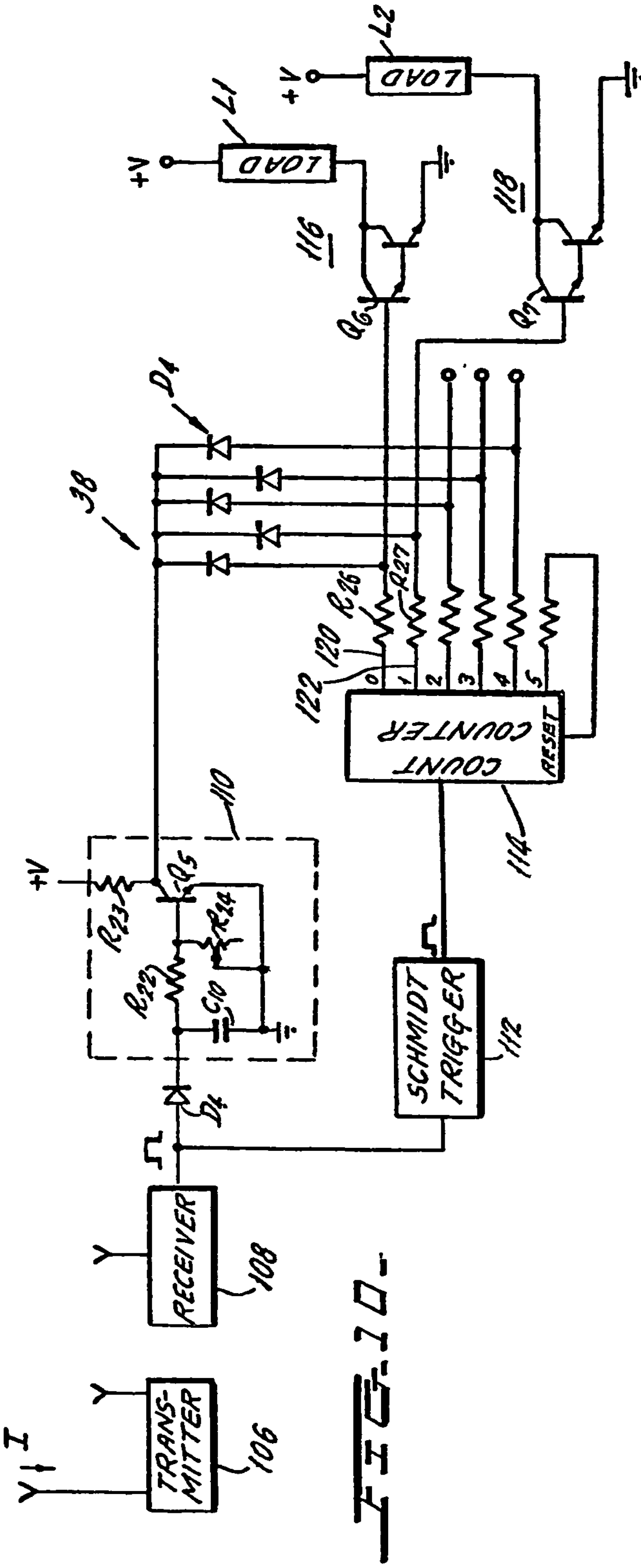


FIG. 10.

FIG. 12A.

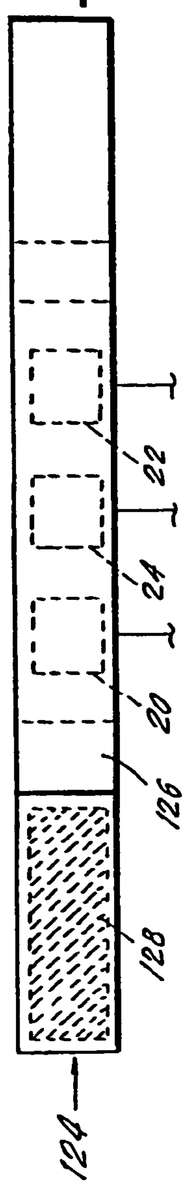


FIG. 12B.

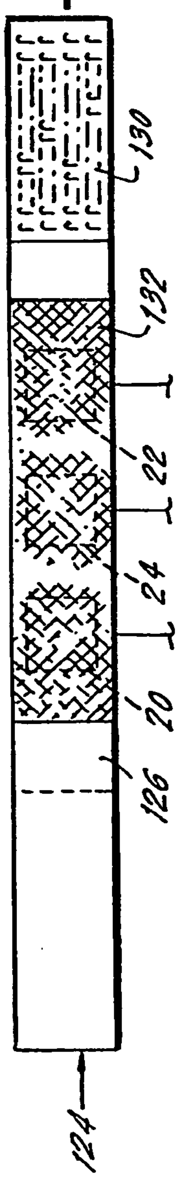
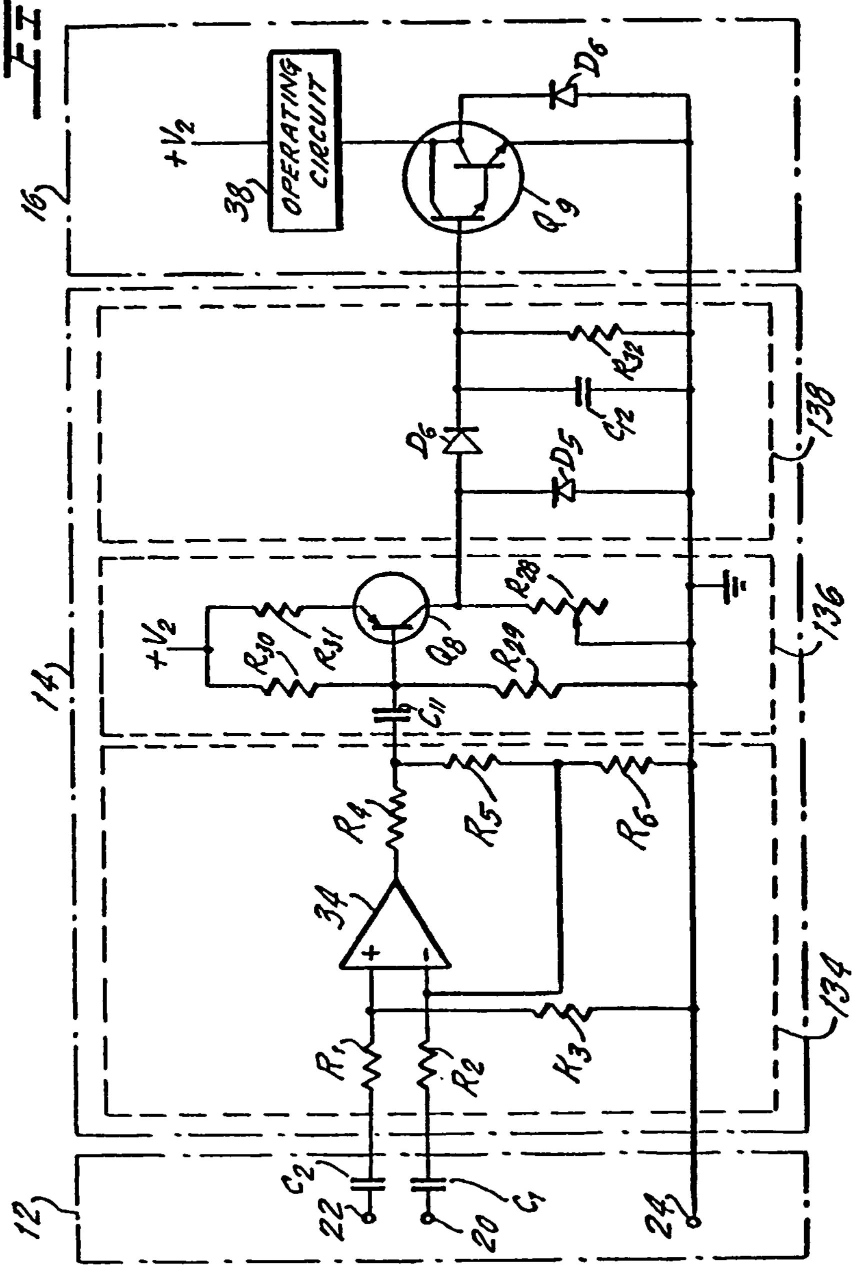


FIG. 13.



SPECIFICATION

Toy controlled by myoelectric potentials

Background of the invention

The present invention relates to a remote control toy, more particularly to a remote control toy which is controlled by myoelectric potentials developed by muscle activity of an operator of the toy.

Myoelectric potentials are developed whenever individual muscles are contracted or relaxed. When muscles close to the skin are activated, the myoelectric potential appears in the skin. This potential may be detected by appropriate pickup circuitry and utilized to control a toy capable of producing at least one human perceptible output.

The use of myoelectric potentials for controlling prosthetic devices has been known for some 15 years. Exempletory of such uses is U.S. Patent Number 3,883, 900. Generally speaking, these prosthetic devices include a control circuit which generates an output signal whose magnitude varies as a function of the magnitude of the myoelectric potentials and a motor whose operation is controlled by the output signal. Similar uses of electro myographic potentials are disclosed in U.S. Patent Number 3,628,538 (biological feedback) and U.S. Patent Number 3,106,371 (aircraft control system).

Brief description of the invention

While electromyographic potentials have been used in various medical applications, their use in the toy field is entirely novel. It has long been a primary goal in the toy field to provide a toy which creates the illusion of a "live" or "thinking" toy. To this end, the art has provided various preprogrammed and remote controlled toys. The preprogrammed toys are desirable since they perform in a seemingly intelligent manner completely independent of an operator of the toy. The drawback to these toys is that their actions are predetermined by the program and cannot be modified once a program has begun. As such, these toys cannot react to instantaneous situations encountered by the toy. For example, a preprogrammed toy car will travel along a predetermined course dictated by the car's program. This will provide the illusion of a "thinking" or "live" toy if there are no obstacles along the predetermined path of travel. This illusion is quickly dissipated if an obstacle is placed along that path and the car runs into the obstacle.

In contrast to the foregoing, remote controlled toys, such as radio controlled cars, provide the ability to react to such changing situations. The illusion of the "thinking" and "live" toy is, however, severely decreased by the obvious movement of the operator of the toy in controlling the toy. For example, control over most radio controlled cars is provided by a control box which includes an operating lever which is moved by the operator of the toy. The required movement of the lever is sufficiently great that any third party observing the operation of the toy would perceive to this movement thereby significantly diminishing the desired illusion.

Utilizing electromyographic potentials, the present invention enables instantaneous remote control of the toy without any apparent motion on the part of the operator. For example, electrodes in contact with the forehead of the operator of the toy can pick up myoelectric potentials generated when the operator of the device clenches his teeth. Such muscle activity is easily controlled by the operator of the device and is not easily perceived by third parties. The electrode may be easily concealed under a hat housing both the electrodes and a radio transmitter which transmits radio signals indicative to the myoelectric potential developed in the forehead of the operator. By providing a toy including a radio receiver whose output controls the operator of the toy, it is possible for the operator to control all functions of the toy without any perceptible movement on his part. In this way, the present invention meets the long desired goal of producing the illusion of a "thinking" or "live" toy. The foregoing desirable results are obtained by providing a remote controlled toy, comprising:

a toy capable of producing at least one human perceptible output:

a sensor circuit adapted to contact the skin of an operator of the toy and responsive to a myoelectric potential developed by muscle activity of the operator for providing an electrical signal having a magnitude proportional to the degree of the muscle activity;

an amplifier circuit responsive to the electrical signal for generating a control signal whose magnitude varies as a function of the muscle activity; and

a control circiuit responsive to the control signal for operating the toy as a function of the muscle activity.

Brief description of the drawings

For the purpose of illustrating the invention, there is shown in the drawings several embodiments which are presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

Figure 1 is a general block diagram of the present invention.

Figure 2 is a circuit diagram of the block diagram of Figure 1.

Figure 3 is a cross-sectional view of a hat which may be utilized in connection with the present invention.

Figure 4 is a circuit diagram of an operating circuit utilized in a first embodiment of the present invention.

Figure 5 is a graph illustrating one mode of operation of the present invention.

Figure 6 is a circuit diagram of an operating circuit utilized in a second embodiment of the present invention.

Figure 7 is a circuit diagram of an operating circuit utilized in a third embodiment of the present invention.

Figure 8 is a circuit diagram of an operating circuit utilized in a fourth embodiment of the present invention.

Figure 9 is a timing diagram for the circuit of Figure 8.

Figure 10 is a circuit diagram of an operating circuit utilized in a fifth embodiment of the present

invention.

Figure 11 is a time diagram for the circuit of Figure 10.

Figures 12A and *12B* are front and rear views, respectively, of a head band which may be utilized in connection with the present invention.

Figure 13 is a circuit diagram of a second embodiment of the block diagram of Figure 1.

Detailed description of the invention

Referring now to the drawings wherein numerals indicate like elements, there is shown in Figure 1 a block diagram for a remotely controlled toy constructed in accordance with the principles of the present invention and designated generally as 10. Toy 10 comprises a sensor circuit 12, an amplifier circuit 14, a control circuit 16 and a toy 18 capable of producing at least one human perceptible output. By way of example, toy 18 is illustrated as a remote controlled toy car.

The sensor circuit 12 preferably comprises a plurality of electrodes adapted to contact the skin of the operator of the toy. The sensors are responsive to myoelectric potentials developed by muscular activity of the user and provide an electrical output signal having a magnitude proportional to the degree of the muscular activity. The amplifier circuit 14 receives the signal generated by the sensor circuit 12 and generates a control signal V_C whose magnitude varies as a function of the muscle activity. The control circuit 16 receives the control signal V_C and operates the toy 18 as a function of the degree of muscle activity. As will become clear below, various elements of the control circuit 16 may be housed in the toy 18.

The toy 18 may be any remotely controlled toy which is capable of producing at least one human perceptible output. For example, the toy 18 may be a toy car which operates in either a forward or a reverse mode. Other possible embodiments vary from very simplistic toys such as a toy dog which barks on command to relatively complex toys such as remote controlled TV games.

Applicants' invention may be better understood with reference to Figure 2. In the embodiment of Figure 2, the sensor circuit 12 comprises three electrodes 20, 22 and 24 which are firmly secured to the operator of the toy in the area where a myoelectric potential is developed. The electrodes may be secured to any area of the skin of the operator. By way of example, the three electrodes may be attached to the forehead of the user in the area just above the eyes. The operator of the toy may then develop a myoelectric potential in the forehead area by clenching his or her teeth. The magnitude of the myoelectric activity, and therefore the output signal provided by the electrodes, will vary as a function of the degree to which the operator clenches his or her teeth.

One possible apparatus for securing the electrodes 20 through 24 to the forehead of the operator is illustrated in Figure 3. Figure 3 is a cross-sectional view of a hat 26 which is adapted to be worn by the operator of the toy. The electrodes 22 through 24 are coupled to the hat 26 by an elastic material 28 which urge the electrodes 20 through 24 into firm contact with the forehead of the operator. The elastic material may be foam rubber or any other appropriate material. Since Figure 3 is a cross-sectional view of the hat 26, only the middle electrode 24 is shown. Outer electrodes 20 and 22 are disposed on either side of electrode 24. Electrodes 20-24 are coupled to amplifier circuit 14 via a pluarality of wires 30. Amplifier circuit 14 is preferably housed in an aluminum housing 32 coupled to the top of the hat 26. To insure proper electrical contact between the sensors 20 through 24 and the forehead of the user, the electrodes are preferably gold plated copper.

A second possible apparatus for securing the electrodes 20-24 to the forehead of the operator is illustrated in Figures 12A and 12B. In this embodiment, an elastic headband 124 is used to secure the electrodes 20-24 to the forehead of the operator. Figure 12A is a front view of the headband. Figure 12B is a rear view thereof.

Headband 124 comprises an elastic strip 126 having a Velcro (Registered Trade Mark) fastener coupled thereto. Particularly the "hook end" portion 130 of the Velcro fastener is fastened to one end of the elastic band 126 while the "loop end" portion 128 is fastened to the other end thereof. The electrodes 20-24 are preferably gold plated copper and are glued to one side of the elastic strip. A gauze-like material 132 is secured to the elastic strip 126 over the electrodes. Water is applied to the absorbent gauge-like strip 132 thereby insuring good electric contact between the electrodes and the forehead of the operator of the toy.

Referring again to Figure 2, the outer electrodes 20 and 22 are connected to the inverting and non-inverting inputs of an operational amplifier (hereinafter Op. Amp.) 34, respectively. Electrode 20 is coupled to the inverting input of Op. Amp. 34 via coupling capacitor C1 and resistor R1. Electrode 22 is coupled to the non-inverting input of Op. Amp. 34 via coupling capacitor C2 and a voltage divider comprising resistors R2 and R3. The central electrode 24 is connected to ground.

Operational amplifier 34 is connected to operate as a difference amplifier. That is, its output if fed back to its inverting input terminal via resistors R4, R5 and R6. So connected, operational amplifier 34 generates an output signal V_A whose magnitude is directly proportional to the difference between the voltages applied to its inverting and non-inverting inputs. Since the potential at electrode 20 is fed directly to the inverting input of Op. Amp. 34 and the potential at electrode 22 is fed to the non-inverting input of Op. Amp. 34 through the voltage divider R2, R3, a detectable voltage V_A is generated at the output of Op. Amp. 34 whenever a myoelectric potential is generated in the skin of the operator in the area surrounding sensors 20 through 24.

The output signal V_A is applied to the inverting input terminal of a second operational amplifier 36 via a coupling capacitor C3 and resistor R9. A variable filter circuit comprising C4 and R8 is coupled between the output V_A of Op. Amp. 34 and ground. Since the myoelectric signal is an a.c. signal, it is possible to vary the percentage of the output signal V_A which is applied to the non-inverting input

of Op. Amp. 36 by adjusting the position of the slide arm of potentiometer R_8. In this manner, potentiometer R_8 serves as the sensitivity potentiometer for amplifier circuit 14 and determines the magnitude of muscle activity required to obtain a desired output of the toy.

The non-inverting input of Op. Amp. 36 is connected to ground through resistor R10. Its output is fed back to its inverting input via resistors R11 and R12. A filter capacitor C5 is also coupled between the output and the non-inverting input of Op. Amp. 36. So connected, Op. Amp. 36 operates as an inverting amplifier and generates an output signal V_B whose magnitude varies as a function of the magnitude of the signal (KV_A) applied to the non-inverting input of Op. Amp. 36.

Output signal V_B is applied to the base of transistor Q1 via coupling capacitor C6. Transistor Q1 is preferably an NPN transistor whose emitter is coupled to ground through resistor 14 and whose collector is connected to a biasing potential +V1 via resistor R13. When the magnitude of output signal V_B is below the cut-off voltage of transistor Q1, transistor Q1 is biased off and the control voltage across capacitor C7 rises to +V1 volts (the biasing voltage applied to resistor R13). As the magnitude of the output signal V_B increases, transistor Q1 begins conducting. At this point, the stored voltage across capacitor C7 begins discharging through transistor Q1 and the magnitude of the voltage V_C decreases. Particularly, V_C decreases as an inverse function of the magnitude of the voltage V_B as long as the magnitude of the input voltage V_B remains within the operating range of transistor Q1. When the magnitude of voltage V_B becomes sufficiently large to drive transistor Q1 into saturation, capacitor C7 totally discharge through resistor R14 and V_C reduces to zero volts. In the embodiment illustrated in Figure 2, the magnitude of the control signal V_C generated by amplifier circuit 14 varies as an inverse function of the magnitude of the myoelectric potential generated by the operator of the toy. If desired, the circuit may be modified such that the output signal V_C varies as a direct function of the myoelectric potential. Several other variations on the amplifier circuit of Figure 2 will be apparent to those skilled in the art. One such variation is illustrated in Figure 13. As shown therein, amplifier circuit 12 includes a difference amplifier stage 134, an amplifier stage 136, and an a.c. to d.c. converter stage 138. Difference amplifier stage 134 is identical to that of Figure 2 and will not be described herein. Amplifier stage 136 includes a transistor Q8, resistors R_{28}-R_{31} and coupling capacitor C_{11}. The output of the difference amplifier stage 134 is applied to the base of transistor Q8 via coupling capacitor C11. The values of resistors R_{28}-R_{31} are chosen to bias transistor Q8 into its linear amplification mode. Since the collector circuit of transistor Q8 acts as a constant current source, variation of the trim resistor R_{28} varies the a.c. gain of the amplifier stage 136 and sets the d.c. bias on transistor Q9.

A.c. to d.c. converter stage 138 comprises diodes D_5, D_6, capacitor C_{12} and resistor R_{32}. Diodes D5 and D6 serve to convert the a.c. output of amplifier stage 136 to a fluctuating d.c. signal. Capacitor C_{12} and resistor R_{32} operate to smooth the level of this signal before it is applied to the base of transistor Q9.

In the embodiment illustrated in Figure 13, control circuit 16 has also been modified. Particularly, the Darlington transistor Q9 replaces the transistor Q2 of Figure 2. Transistor Q9 drives the operating circuit 38 in response to the demodulated electromyographic signals picked up by sensors 20-24.

It should be noted at this time that the power circuit feeding the power terminals (not shown) of Op. Amps 34, 36 should include RC isolation circuits for stabilizing and/or isolating the operational amplifiers 34, 36. This is desired to inhibit oscillations which tend to develop in multiple stage amplification circuits.

The control circuit 16 comprises a transistor Q2 and an operating circuit 38 and controls the operator of the toy 18 as a function of the magnitude of the control V_C. Transistor Q2 is preferably a PNP transistor whose emitter is connected to a biasing voltage V2 and whose collector is coupled to operating circuit 38. A filter capacity is connected between the emitter and collector of transistor Q2. The base of transistor Q2 receives control voltage V_C. So connected, transistor Q2 generates an output current I whose magnitude varies as a function of the magnitude of control voltage V_C. If transistor Q2 is biased in its operating range, the magnitude of output current I will vary as an inverse function of the magnitude of voltage V_C. If transistor Q2 is biased into saturation or cut off, current I will be at some value determined by the impedance of control circuit 38 or at zero volts, respectively.

Operating circuit 38 will take various forms depending upon the particular type of toy being controlled and the mode of operation of that toy. Four primary modes of operation are possible; linear control, linear limit control, two-function discrete control and coded digital control. Each of these types of controls will be described separately below.

Linear control

Linear control is used in connection with a toy capable of producing at least one variable human perceptible output; for example a toy train whose speed varies as a function of the current applied to a motor driving the train. In such an embodiment, transistor Q2 is biased to remain in its operating range through substantially the entire range of elecromyoptic inputs. So biased, the magnitude of current I varies in proportion to the magnitude of control voltage V_C. In the embodiment illustrated in Figure 2, the magnitude of the current I will vary as an inverse function of the control voltage V_C and as a direct function of the myoelectric potential developed by the operator of the toy.

In an embodiment of this type, operating circuit 38 can take the form illustrated in Figure 4. As shown therein, operating circuit 38 includes an opto-isolator 40, a transistor Q3, a diode D1 an a filter capacitor C9. Opto-isolator 40 includes a light source 42 and a light sensitive Darlington transistor 44. Light source 42 generates an optical output whose magnitude varies as a function of the input current I. The light generated by light source 42 is detected by transistor

44 which generates an output signal at its emitter whose magnitude varies as a function of the magnitude of the radiation generated by light source 42. This output signal is applied to the base of transistor Q3 and controls the degree to which transistor Q3 conducts. The collector of transistor Q3 is directly connected to the positive input terminal of a power supply 43 which powers the electric train, and its emitter is connected to the negative terminal of the transformer through a diode D1. Since the base voltage to transistor Q3 varies as a function of the magnitude of the radiation generated by light source 42, the current through transistor Q3, and therefore the voltage across the motor of the train, varies as a function of the magnitude of current I. In this way, the speed of the motor will vary as a direct function of the current signal I and therefore as a direct function of the myoelectric potential gènerated by the user of the toy. It should be noted that the opto-isolator 40 is utilized to isolate the operator of the device from accidental breakdown in the power supply which might expose the operator to a dangerously high voltage generated by the power supply 43. Of course, other isolating circuitry could be utilized.

Linear Limit control

Linear limit control may best be understood with reference to the graph in Figure 5. Linear limit control is utilized when the toy being controlled is capable of operating in first, second and third modes. Control circuit 16 will operate the toy in the first mode when the myoelectric potential is below a first predetermined value A, in the second mode when the myoelectric potential is above the first predetermined value A but below a second predetermined value B, and in the third mode when the myoelectric potential is above the second predetermined value B. The second mode is a linear controlled mode wherein the magnitude of some human perceptible output of the toy is varied as a function of the magnitude of the myoelectric potential. The first and third modes may be, for example, the stop and reverse modes of a remote control car, respectively. In such a case, the car will be stopped when the myoelectric potential is below the first predetermined value A, will go forward at a speed proportional to the myoelectric potential when the myoelectric potential is above the first value A but below the second value B, and will go in the reverse direction when the myoelectric potential is above the second value B.

One possible operating circuit which could be utilized in connection with a linear limit control is illustrated in Figure 6. As shown therein, operating circuit 38 includes a pair of operational amplifiers 46 and 48 and a power circuit 50. Power circuit 50 comprises a transistor Q4, and power supply 52 and a diode D2. The base of transistor Q4 receives a control voltage (across resistor R16) which is proportional to the current I. The control voltage determines the magnitude of the current through transistor Q4 and therefore the magnitude of the current applied to the motor. As such, power circuit 50 drives the motor of the car at a speed whose magnitude is directly proportional to the myoelectric potential generated by the operator of the toy.

Op. Amp. 46 monitors the magnitude of the current I and causes the car to stop whenever the myoelectric potential generated by the operator of the toy is less than the first predetermined value A illustrated in Figure 5. Op. Amp. 46 operates as a comparator and generates an enabling signal at its output terminal 54 whenever the voltage across resistor R16 is greater than the biasing voltage V_{bias} applied to its inverting input terminal. Biasing voltage V_{bias} is chosen to correspond to the first predetermined value A such that Op. Amp 46 generates an enabling signal at its output 54 whenever the magnitude in the myoelectric potential rises àbove the first predetermined value A. The output of Op. Amp. 46 is connected to a brake solenoid housed in the toy car. The car brake (not shown) is spring biased into the braking position such that the toy car is normally braked. When the myoelectric potential rises above the predetermined value A, a solenoid connected to the brake is enabled by the enabling signal generated by Op. Amp. 44, causing the brake to be released. Accordingly, the car will stop whenever the myoelectric potential generated by the operator of the toy falls below the potential value A.

Op. Amp. 48 monitors the magnitude of current I and causes the car to reverse whenever the myoelectric potential generated by the operator of the toy is greater than the second predetermined value B illustrates in Figure 5. Op. Amp. 48 operates as a comparator and generates an output signal at its output 56 whenever the magnitude of the voltage across resistor R16 rises above the biasing potential V'_{bias} applied to its non-inverting input terminal. The magnitude of the biasing voltage V'_{bias} is chosen to correspond to the second predetermined myoelectric potential B. Accordingly, Op. Amp. 48 generates an output signal at its output terminal 56 whenever the myoelectric potential generated by the operator of the toy rises above the second predetermined value B. The output of Op. Amp. 48 is applied to a reversing switch which reverses the polarity of the motor driving the car. Accordingly, whenever the myoelectric of potential generated by the operator of the toy rises above the second predetermined value B, the reversing switch will be enabled and the toy car will be operated in the reverse direction.

Two-function control

Two-function control is used in connection with a toy capable of producing first and second distinct human perceptible outputs; for example, a toy dog which barks whenever an enabling signal is applied to an audio circuit housed in the doll.

When operating in the two-function control mode, transistor Q2 is biased to operate in a switching mode wherein transistor Q2 is biased on or off the function of the magnitude of the control signal V_C generated by amplifier circuit 14. By properly selecting the setting of the slide arm of potentiometer R8, transistor Q2 will be biased on whenever the electromyographic potential developed by the operator of the device rises above some predetermined value and will be biased off whenever the electromyographic potential falls below that predetermined

value. Accordingly, output current I will be at substantially the zero level whenever the electromyographic potential is below the predetermined value and will be at some predetermined constant level whenever the electromyographic potential is above that predetermined value.

One possible operating circuit which could be utilized in connection with the two-function toy dog described above is illustrated in Figure 7. As shown therein, operating circuit 38 includes a transmitter circuit 58, a receiving circuit 60, a relay 62, a normally open switch 64, an audio circuit 66 and a speaker 68. With particular reference to the embodiment of Figure 3, the transmitter circuit 58 would normally be housed in the housing 32 while the remaining elements of operating circuits 38 would normally be housed in the toy dog.

The transmitter circuit 58 is a standard transmitter circuit which generates a radio signal having a predetermined magnitude and frequency whenever the current signal I is applied thereto (i.e. whenever transistor Q2 is biased on). The receiver circuit 60 is also a standard receiver circuit which generates an output signal I' whenever it detects the radio signal generated by a transmitter 58. Transmitter and receiver circuits 58 and 60 are standard devices which will not be described in further detail.

The output signal I' generated by receive circuit 60 is applied to relay 62. Diode D3 protects a switching transistor in the receiver from reverse currents. Whenever relay 62 receives the input signal I', it closes normally open switch 64 and enables audio circuit 66. Audio circuit 66 is a standard audio circuit which generates an audio frequency electrical signal at its output 70 whenever normally open switch 64 is closed by relay 62. The audio frequency electrical signal generated by audio circuit 66 is applied to speaker 68 thereby generating the desired audio output.

Coded digital control

Coded digital control is utilized to control a toy having a plurality of discrete human perceptable outputs. For example, such a control may be conveniently used in connection with a toy robot which is capable of forward motion, reverse motion, and a head rotating motion.

One possible operating circuit which could be utilized in connection with a coded digitally controlled robot is illustrated in Figure 8. In this embodiment, it is assumed that transistor Q2 is biased to operate in a switching mode whereby it is biased on whenever the myoelectric potential generated by the operator of the toy is above some predetermined value A and is biased off whenever the myoelectric potential generated by the operator of the toy is below that predetermined value. As a result, the current I will flow through resistor R21 only when the myoelectric potential generated by the operator rises above that predetermined value.

As shown in Figure 8, the operating circuit 38 comprises a logic circuit 72 and a control circuit 74. Logic circuit 72 comprises a resistor R21, a Schmitt Trigger 76, a flip-flop 78, a counter 80 and a timer circuit 82 and generates an output signal on line 83 which is indicative of the number of times the myoelectric potential generated by the operator rises above a predetermined value within a predetermined time period. The control circuit 74 comprises a decoder circuit 84, a first power circuit 86, a second power circuit 88, a reverse switch 90 and a brake solenoid 92 and causes the toy robot to exhibit forward motion, reverse motion or a head rotating motion as a function of the output signal generated by logic circuit 72.

The predetermined time period during which counter 80 counts the number of times the myoelectric potential rises above a predetermined value A is determined by Schmitt Trigger 76, flip-flop 78 and timer circuit 82. The Schmitt Trigger 76 is a standard one shot which generates an output pulse having a predetermined pulse width each time the voltage at its input (the voltage across resistor R21) rises above a predetermined value. By properly selecting the parameters of current I, resistor R21 and one shot 76, it is possible to cause Schmitt Trigger 76 to generate a single positive going output pulse each time the myoelectric potential generated by the operator rises above the predetermined value A. The pulse generated by Schmitt Trigger 76 is applied both to the count input terminal of counter 80 and the set input of flip-flop 78.

Flip-flop 78 is a standard flip-flop whose output goes "high" each time a positive going pulse is applied to its set input and goes "low" each time an input pulse is applied to its reset input. The output of flip-flop 78 is applied to the input of timer circuit 82. As used herein, the term "high" refers to a signal magnitude which is above a predetermined value and corresponds generally to a binary "I". The term "low" refers to a signal magnitude which is below the predetermined value and corresponds generally to a binary "0".

Timer circuit 82 is a standard timer circuit which generates a positive going output pulse a predetermined time after a "high" signal is applied to its input; for example, one second after a "high" is applied to its input terminal. By adjusting the time delay of timer circuit 82, the time period during which the logic circuit 72 counts the number of times the myoelectric potential rises above the predetermined value may be adjusted. The output pulse generated by timer circuit 82 is directly applied to the reset input of flip-flop 78 and the enable input of decoder circuit 84. The output pulse of timer circuit 82 is also applied to the reset input of counter 80 via a time delay circuit 81. The function of time delay circuit 81 is described below.

As long as the output of flip-flop circuit 78 is "high", additional pulses generated by Schmitt Trigger 76 will have no effect on the output of flip-flop 78. Accordingly, flip-flop 78 responds only to the first pulse generated by Schmitt Trigger 76 during the predetermined time period established by timer circuit 82. At the end of the predetermined time period, the pulse generated by timer circuit 82 is applied to the reset input terminal of flip-flop 78 causing the output of flip-flop 78 to go "low". The next pulse generated by one shot 78 will again cause the output of flip-flop 78 to go "low" and will cause timer circuit 82 to again begin timing out.

Counter circuit 80 is preferably a digital counter which counts the number of pulses applied to its count input terminal and generates a digital signal on line 83 representative of the instantaneous value of the count in counter 80. The count in counter 80 is reset to 0 each time a reset pulse is applied to its reset input terminal by delay circuit 81. In the embodiment illustrated in Figure 8, it is assumed that counter circuit 80 has a maximum count of 4 and that additional pulses applied to its count input terminal after it has reached its maximum count will have no effect upon the count in counter 80. It will be apparent from the foregoing that counter circuit 80 counts the number of pulses generated by Schmitt Trigger 76 (and therefore the number of times the myoelectric potential generated by the operator of the toy rises above the predetermined value) during the predetermined time period established by flip-flop 78 and timer circuit 82.

The operation of logic circuit 72 may be best understood with reference to Figure 9. Figure 9a illustrates the voltage across resistor R21 which is applied to Schmitt Trigger 76. Figure 9b illustrates the output pules generated by Schmitt Trigger 76. Figure 9c illustrates the output of flip-flop 78. Figure 9d illustrates the output of timer circuit 82 and Figure 9e illustrates the output of delay circuit 81.

As shown in Figure 9a, a first pulse appears across resistor R21 at time t0. In response to this pulse, Schmitt Trigger 76 generates an output pulse (Figure 9b) which sets flip-flop 78 which in turn causes timer 82 to begin timing out. At time t1 (after a predetermined time period T) timer circuit 82 generates an output pulse which resets flip 78 and initiates the timing of delay circuit 81. Shortly thereafter, delay circuit 81 generates an output pulse which is applied to the reset input of counter 80.

In the examples shown, the operator generated three pulses during the time period T. Accordingly, at time t1 the count in counter 80 is three. This count is cleared at time t2.

When the next pulse appears across resistor R21 (at time t0', Schmitt Trigger 76 again generates an output pulse which sets flip-flop 78 and reinitiates the timing out of the predetermined time period T. In the example shown, only one pulse is generated across resistor R21 during the second predetermined time period T and the count in counter 80 is one at the end of predetermined time period T'.

The output of counter circuit 80 is applied to decoder circuit 84. Decoder circuit 84 is a standard decoder which generates a "high" on only one of its four output lines 94, 96, 98 and 100 at any given instant. Particularly, decoder circuit 84 generates a "high" on that output line 94, 96, 98 or 100 which is addressed by the digital signal on line 83 at the instant at which a positive going pulse is applied to its enable input. Since the pulse generated by timer circuit 82 is applied directly to the enable input of decoder circuit 84 and is applied to the reset input of counter 80 after a short time delay determined by delay circuit 81, the signal on line 83 at the instant that timer circuit 82 generates its output will be representative of the number of times the myoelectric potential generated by the operator of the device rose above the predetermined value A during the predetermined time period set by flip-flop 78 and timer circuit 82. If counter circuit 80 has counted one pulse at the end of the predetermined time period, decoder circuit 84 generates a "high" on line 94. If the count in counter 80 is 2 at the end of the predetermined time period, decoder circuit 84 generates a "high" on line 96. If the count in counter circuit 80 at the end of the predetermined time period is 3, decoder circuit 84 generates a "high" on line 98. If the count in counter circuit 80 is 4 at the end of the predetermined timer period, decoder circuit 84 generates a "high" on line 100.

Line 94 is coupled to a power circuit 86 which applies power to a drive motor 102 which effectuates forward motion of the toy robot. Accordingly, the toy robot will go forward each time a "high" appears on line 94. Output line 96 is applied to a reverse switch 90 which reverses the polarity of motor 102 each time a "high" appears on line 96. So connected the robot will be driven in the reverse direction each time a "high" appears on line 96. Output line 98 is applied to a brake solenoid 92 which is housed in the robot. A brake for the robot is normally spring biased out of the braking position such that the brake is normally released. When a "high" appears on line 98, the brake solenoid is actuated and the brake is moved into its braking position. Finally, output line 100 is applied to power circuit 88 which applies power to a motor 104 which effectuates head rotation of the robot. So connected, the head of the robot will rotate whenever a "high" appears on line 100.

Summarizing the foregoing, control circuit 74 will cause the robot to move in a forward direction, move in a reverse direction, stop, or to rotate its head, as a function of the number of times the myoelectric potential generated by the operator of the toy rises above a predetermined value A during a predetermined time period.

A second possible operating circuit which could be utilized in connection with a coded digitally controlled toy is illustrated in Figure 10. In this embodiment it is assumed that transistor Q2 is biased to operate in a switching mode whereby it is biased on whenever the myoelectric potential generated by the operator of the toy is above some predetermined value A and is biased off whenever the myoelectric potential generated by the operator of the toy is below that value. As a result, a voltage V will be applied to transmitter 106 only when the myoelectric potential generated by the operator rises above the predetermined value A.

As shown in Figure 10, operating circuit 38 comprises a transmitter 106, a receiver 108, a time delay circuit 110, a Schmitt Trigger 112, a counter 114, and first and second power circuits 116 and 118. Receiver 108 is responsive to radio signals generated by transmitter 106 and generates an output pulse each time the myoelectric potential generated by the operator of the toy rises above the predetermined value. The output pulse generated by receiver 108 is applied both to the input of Schmitt Trigger 112 and to the input of timer circuit 110. If desired, the transmitter 106 and the receiver 108 may be

omitted and the pulse generated by transistor Q2 may be applied directly to timer circuit 110 and Schmidt Trigger 112.

Schmitt Trigger 112 is a standard Schmitt Trigger which generates a count pulse responsive to each pulse generated by receiver 108. The count pulse generated by Schmitt Trigger 112 is applied to the count input terminal of counter 114 which is preferably a decade counter which generates a "high" signal on one of its ten output lines as a function of the instananeous count in counter 114. For example, if the instantaneous count in counter 114 is zero, a "high" will appear on output line 120 and a "low" will appear at each of the remaining outputs of counter 114.

Timer circuit 110 comprises a capacitor C10, resistors R22 and R23, potentiometer R24 and transistor Q5. Timer circuit 110 receives the output pulse generated by receiver 108 via diode D4. Timer circuit 110 begins timing out at the trailing edge of the pulse generated by receiver 108. During the time during which timer 110 is timing out, it disables the power circuits 116, 118 by grounding the outputs of counter 114.

Each of the outputs of counter 114 are applied to a different power circuit associated with a different load. In the examples shown, output lines 120 and 122 are coupled to power circuits 116 and 118, respectively, via resistors R126 and R127. In the embodiment shown, it is possible to control as many as nine different loads. The number of loads controlled may be increased by adding additional counters or decreased by utilizing less than all of the output lines of counter 114.

Each of the power circuits 116 includes a Darlington transistor Q6 whose emitter coupled to ground and whose collector is coupled to a load (such as the propulsion motor of a toy robot). The remaining input of the load is applied to a power source generating +V volts. So coupled, power circuit 116 applies power to its load L1 whenever line 120 is "high". Similarly, power circuit 118 will apply power to its load L2 whenever line 122 is "high".

The reset input of counter 114 is coupled to one of the outputs of counter 114 such that the count in the counter resets to zero whenever the instantaneous count in counter 114 reaches a predetermined value. If counter circuit 114 is utilized to control nine different loads, the reset input of counter 114 will be connected to the nine output of the counter such that the count in counter 114 is reset to zero whenever the count in counter 114 reaches nine.

The operation of operating circuit 38 (illustrated in Figure 10) may best be understood with reference to Figure 11. Figure 11a illustrates the output pulses generated by receiver 108. Figure 11b illustrates the output pulses generated by Schmitt Trigger 112. Figure 11c illustrates the output of timer 110.

In the examples shown, it is assumed that the receiver 108 generates output pulses at times t_1, t_3, t_5 and t_6. As shown, the duration and frequency of the pulses generated by receiver 108 are variable and are controlled by the operator of the toy. As soon as the leading edge of the first input pulse is applied to the timing circuit 110, capacitor C10 charges to a predetermined value which causes transistor Q5 to turn on and thereby ground the cathodes of diodes D4. Transistor Q5 remains on and the cathodes of diodes D4 remain grounded until time t_3 which is determined by the duration of the output pulse generated by receiver 108 plus the time constant of capacitor C10 and resistors R22, R24. Capacitor C10 will not begin discharging until the output pulse generated by receiver 108 returns to ground.

Coincident with the leading edge of the first pulse generated by receiver 108 (i.e. at time t_1), Schmitt Trigger 112 generates an output pulse. The output pulse from 112 is applied to the counter 114 and causes the count in counter 114 to increase by one. This count will not effectuate a change in the output loads until after timer circuit 110 has timed out (i.e. at time t_2). At this, the outputs of counter circuit 114 will be enabled and the power circuit, determined by the count in counter 114 will be enabled.

A second pulse is generated by receiver 108 at time t_3. The leading edge of this pulse enables Schmitt Trigger 112 and causes Schmitt Trigger 112 to generate an output pulse which again increases the count in counter 114 by one thereby enables a different load when timer circuit 110 times out (at time t_4).

In the foregoing two examples, it was assumed that only a single pulse was generated by receiver 108 during the time period in which timing circuit 110 is timing out. An example where a plurality of pulses are generated by receiver 108 during a single time period of timer 110 is illustrated at times t_5 and t_6. The leading edge of the pulse generated at time t_6 is sufficiently close to the trailing edge of the pulse generated at time t_5 that capacitor C10 of timer circuit 110 is recharged before the timer circuit has an opportunity to time out. As a result, two output pulses are generated by Schmitt Trigger 112 (at times t_5 and t_6) before timer circuit 110 times out (at time t_7). Accordingly, the count in counter 114 will be increased by two when transistor Q5 turns off and timer circuit 110 times out (i.e. at time t_7).

While two alternate digital control circuits have been shown, several variations of these circuits are possible and are within the broad scope of the present invention.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

CLAIMS

1. A remotely controlled toy, comprising:
a toy capable of producing at least one human perceptible output;
sensor means adapted to contact the skin of an operator of said toy, said sensor means responsive to a myoelectric potential developed by muscle activity of the operator for providing an electrical signal having a magnitude proportional to the degree of said muscle acitivity;
amplifier means responsive to said electrical sig-

nal for generating a control signal whose magnitude varies as a function of said muscle activity; and

control means responsive to said control signal for operating said toy as a function of said muscle activity.

2. The remotely controlled toy of claim 1, wherein said toy is operable in a first and a second mode and wherein said control means:

A) operates said toy in said first mode when the magnitude of said control signal is below a first predetermined value; and

B) operates said toy in said second mode when the magnitude of said control signal is above said first predetermined value.

3. The remotely controlled toy of claim 1 wherein said toy is operable in a first, a second and a third mode and wherein said control means:

A) operates said toy in said first mode when the magnitude of said control signal is below a first predetermined value;

B) operates said toy in said second mode when the magnitude of said control signal is above said first predetermined value but below a second predetermined value, the magnitude of said second predetermined value being greater than the magnitude of said first predetermined value; and

C) operates said toy in said third mode when the magnitude of said control signal is above said second predetermined value.

4. The remotely controlled toy of claim 3 wherein said control means varies at least one of said human perceptible outputs as a linear function of the magnitude of said control signal when said toy is operated in said second mode.

5. The remotely controlled toy of claim 1, wherein said toy is operable in a plurality of modes and wherein said control means includes:

first circuit means responsive to said control signal for generating a digital pulse each time said myoelectric potential developed by the operator of said toy signal exhibits a predetermined characteristic; and

second circuit means responsive to said digital pulses for operating said toy in a mode determined by the number of said pulses, generated during a predetermined time period.

6. The remotely controlled toy of claim 5 wherein said predetermined characteristic is the passage of said myoelectric potential above a predetermined value.

7. The remotely controlled toy of claim 1 wherein said control means varies at least one of said human perceptible outputs as a linear function of the magnitude of said control signal.

8. The remotely controlled toy of claim 1 wherein said toy is powered by a power source which is potentially dangerous to said operator and wherein said toy further includes isolating means for electrically isolating said sensor means from said voltage.

9. The remotely controlled toy of claim 8 wherein said isolating means is an opto-isolator.

10. The remotely controlled toy of claim 1 wherein said sensor means comprises:

a plurality of electrodes; and

means for firmly securing said electrodes to the skin of the operator of said toy.

11. The remotely controlled toy of claim 10 wherein said electrodes are gold plated.

12. The remotely controlled toy of claim 10 wherein said securing means is adapted to secure said electrodes to the forehead of the operator of said toy.

13. The remotely controlled toy of claim 12 wherein said securing means comprises a hat and means mounted in said hat for biasing said electrodes against the forehead of the user of said toy.

14. The remotely controlled toy of claim 13 wherein said control means includes a radio transmitter and a radio receiver and wherein said amplifier means and radio transmitter are housed in said hat and said radio receiver is housed in said toy.

15. The remotely controlled toy of Claim 1 wherein said sensor means comprises a plurality of electrodes, a water absorbent material and means for biasing said electrodes against said water absorbent material and said water absorbent material against the skin of an operator of said toy.

16. The remotely controlled toy of Claim 15 wherein said biasing means comprises an elastic band having a Velcro (Registered Trade Mark) fastener attached thereto.

17. The remotely controlled toy of Claim 1 wherein said amplifier means comprises:

A) second amplifier means for generating an a.c. signal whose magnitude varies as a function of said muscle activity;

B) a.c. to d.c. converting means for converting said a.c. signal to a d.c. biasing signal, said d.c. biasing signal defining said control signal.

18. The remotely controlled toy of Claim 17 wherein said second amplifier means comprises an operational amplifier coupled to operate as a comparator, the inverting and non-inverting imputs of said operational amplifier being coupled to first and second electrodes, respectively, said electrodes defining part of said sensor means.

19. The remotely controlled toy of Claim 18 wherein said second amplifier means further includes a transistor coupled to the output of said operational amplifier and biased to operate in its linear amplification mode.

20. A remotely controlled toy substantially as herein described with reference to and as shown in the accompanying drawings.

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